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# VALUATION OF PLANT VARIETY PROTECTION CERTIFICATES

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## ABSTRACT

Hedonic pricing is used to value certificates of plant variety protection for soybean seed in New York. The estimated price premium of 2.3 percent (.7 ¢/lb.) is low, and another indicator that US Plant Breeders' Rights protection likely provides inadequate incentives for breeding investment. Soon the Congress will decide on amending the Plant Variety Protection Act to strengthen protection. The current results suggest strengthening is needed, but additional study is required to determine if the proposed amendments are optimal.

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Since 1970 the United States has granted certificates of plant variety protection, patent-like protection for open pollinated plant varieties[1]. Initially the Plant Variety Protection Act (PVPA) (7 USC Sec. 2321 *et seq.*) was passed with little public attention, but a few minor amendments[2] adopted in December 1980 were proceeded by an outpouring of public concern and disapproval (summary in Claffey). The issues raised incorporated matters of seed prices, dominance of the breeding sector by private firms, food prices, structure of farming and related issues, many of which have been more recently voiced in conjunction with biotechnology. Additionally, and of particular interest here, the concentration of certificates within a relatively small number of private firms was noted. Size economies in breeding and/or securing protection could lead to concentration in the sector. In response the Department of Agriculture, which houses the Plant Variety Protection Office (PVPO), the administrative body, commissioned a study of the first ten years under the Act (Butler and Marion). That study, while urging the maintenance of public breeding as a source of competition, found few of the major fears were realized in practice (see below).

Over a score of years later UPOV, the international convention, adopted a revised 1991 convention incorporating several potentially major changes. In brief these include a national option for dropping "Farmers' Exemption", and the creation of 'dependency' rights (see below). The US, a signatory to the 1978 convention, must now decide whether or not to accede to this new version. Such changes have been proposed by Senator Kerrey as an amendment to the PVPA, the first step to ratification.

The purpose of this article is the measurement of the economic value of certificates of plant variety protection, the return to certificate holders beyond that explainable by yield differences and other variety characteristics. If the premium is "large" the PVPA in its present form is interpreted as providing notable investment incentives. A small premium, however, suggests the current incentive may be inadequate to bring forth a socially optimal level of investment in plant breeding[3]. UPOV's 1991 convention enhances the level of PVP and thereby provides one means of strengthening the present Act. The results presented here, while

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[1]Asexually propagated plants are protectable under the Plant Patent Act of 1930, incorporated into the Patent Act of 1954 (35 USC Sec. 161-2).

[2]Principally an extension of protection to vegetables and lengthening of the duration of protection to 18 years so that the US would qualify for membership in UPOV, the international convention, which was subsequently joined.

[3]Investment will come from both private firms and universities which use the royalties from protected varieties to support breeding programs. For the case of Cornell University see Lesser 1987(a).

insufficient in themselves for determining the appropriateness of the 1991 Convention for serving the public interest in the US, will nonetheless be useful for legislators called upon to vote for or against the revisions. Their decision will be all the more complex in the present climate of ambivalence regarding agrobiotechnology even though in the US the two issues are not directly linked[4].

The results indicate that the PVPA is associated with limited economic value, only a 2.3 percent price premium for soybean varieties in New York in 1993. If these results are replicated in other states, then there is reason to believe the PVPA needs strengthening[5]. There is, moreover, corroborative evidence that private firms are reducing the use of PVPA while seeking other more effective means for recovering their investments in plant breeding. With declining public funding for plant breeding, that trend by the private sector should be a matter of public attention.

## Issues in Plant Variety Protection

Like patents, certificates of plant variety protection allow the owner to exclude others from variety use, allowing a period free from direct competition for recovering the research investment. Unlike patents, however, that right is limited in two significant respects, known as the **breeders' exemption** and the **farmers' exemption**. The breeders' exemption or privilege (7 USC Sec. 2544) explicitly allows breeders the right to use protected varieties for subsequent breeding and to sell the derivative varieties so long as ongoing use of the protected variety is not required (as with hybrids)[6]. The farmers' exemption (Sec. 2543) permits farmers to save and plant seed as well as to sell it in small quantities, but not by variety name. These two exemptions notably reduce the protection awarded compared to patents. Farmer seed sales are particularly troubling for private firms[7].

In another dimension as well, PVPA allows limited protection. This is the scope of protection, the degree of distinctiveness required (or close copying

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[4]US Law and practice favor the patenting of products of biotechnology, including seeds, which will be unchanged by the revision of UPOV. However, European patent law contains a clause prohibiting the patenting of "plant or animal varieties" (European Patent Convention Article 53(b)) which, while not totally preventing the use of patents for seeds due to the interpretation of the term 'variety', does mean the dependency concept has more relevence for biotechnology there. For further information see e.g., OECD, Chap. VII; Crespi.

[5]That recommendation is made largely on theoretical grounds because the empirical relationship between aspects of intellectual property rights legislation and investment is poorly documented (see Lesser 1991, Ch. IV).

[6]There is no statutory research exemption in US or any other national patent law, although it is implicit. Bent argues that the allowable exemption is broad, but that interpretation is open to debate.

[7]It can be noted that the US is the only country to allow farmers to sell protected varieties while all members of UPOV presently permit farmers to reuse seed on their own farms.

permitted) (Sec. 2401(a)(1)). In the US the distinctiveness requirement has been interpreted to be satisfied by any difference claimed by the applicant, however minor or unrelated to the intended uses of the plant[8]. For example, the distinct attribute of one soybean variety protected in 1991 was white flowers compared to the purple ones of a parent. The allowance of close substitutes encourages what has been called wasteful "cosmetic breeding". It also limits the monopoly power associated with intellectual property protection while reducing the incentive to invest in plant breeding.

These and other factors led Butler and Marion to conclude (p. 79), "Both benefits and costs appear to be modest. There is no evidence that PVPA has triggered massive investments in R&D. ... However, there is also little evidence of substantial public costs from PVPA." My own interpretation is that the industry overestimated the benefits of PVPA when, for example, increasing the number of soybean breeders from two in 1964 to 63 in 1984 (Brim Table 3). It is said that every major firm has a virtual copy of all competitors' varieties within a few years following release. Hence my earlier statement that the PVPA protects the variety name, not the germplasm itself (Lesser 1987(c)). Users, though, may not recognize the similarities across brands.

The 1991 UPOV revisions in part address these limitations by (a) making the farmers' exemption optional (Article 15(2)) and (b) introducing the concept of dependency (Article 14(5))[9]. Of these, the dependency notion is potentially the most far reaching and complex. Dependency allows the breeder of a protected base ("initial") variety to control the commercialization of derivative ("essentially derived") varieties. Derivative varieties must retain the "expression of the essential characteristics ... of the initial variety" and may be created by "the selection of a natural or induced mutant ... or transformation by genetic engineering" (Article 14(5)). Dependency rights are non-pyramiding; if A is the initial variety and B and C are derivative, then both B and C pay royalties to A[10]. But C cannot pay royalties to B, since B is already dependent. The definition and application of these terms is presently under study by a UPOV committee. Practical implications depend heavily on the outcome of that process. What is evident at this point is that the revised Convention will enhance the strength of protection, especially for those doing the

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[8]In Europe the combination of statistical tests for establishing distinctiveness in the allowed dimensions and the separate EC marketing requirements for food crops means the situation there is quite different from the US. See Lesser 1987(b).

[9]Other notable changes not directly pertinent to the US are: (a) include a definition of variety (Article 1 (vi)), (b) require that all genera and species be protectable within three years (Article 3), (c) drop the ban on double protection (Article 2), and (d) extend protection to the harvested materials of protected varieties and products made directly from harvested materials (Article 14 (2 and 3)).

[10]For a further discussion see Lesser 1993.

longer term "background breeding", the introduction, for example, of genes from wild relatives[11].

The balance of the factors involved is indeterminate at present and in all likelihood will not be known until and if the modification has been in place for some time. Legislators must then make a decision without much information on the likely consequences. In such an environment it would be valuable to know more about the effects of the existing PVPA legislation, and in particular if the incentives allowed appear either excessive or inadequate. The following analysis is intended to answer that question in part.

## Empirical Analysis

The approach to be used here is the application of hedonic pricing analysis to 1992 test data for soybean varieties in New York State. Hedonic pricing measures the marginal value attributed to variety traits by the market. In this instance the value of certificates of plant variety protection, distinct from other variety attributes like yield, is the factor of interest. A high value is indicative of strong protection while a low value suggests limited protection, potentially indicating inadequate stimulus for an optimal level of private investment.

Soybeans were selected for analysis because of their status as the leading recipient of PBR in the US. Foster and Perrin have shown that the attributes of a crop, especially its market value, explain the proportion of certificates issued. The choice of New York was purely a convenience matter. New York is not a major soybean producing state, so the results reported here should be replicated elsewhere for confirmation, but there is no available evidence that the NY soybean seed market functions notably differently from other areas.

The approach to hedonic pricing taken here is that of seeds as an input into the production process such that farmers will select varieties in accordance with their attributes[12]. The hedonic price function will then express price as a function of the variety attributes. Assume a competitive market with farms maximizing profits according to an input characteristic production function, $f_y(z)$. The first order conditions of the profit maximization problem with variety attribute arguments of the production function results in an hedonic price function:

$$P_x = R_y \sum_{k=1}^{m} \left[ \frac{\partial f_y}{\partial z_{ky}} \right] \left[ \frac{\partial z_{ky}}{\partial x_y} \right], \qquad (1)$$

[11]Faucher is using game theory procedures to investigate the implications of dependency on the incentive to invest and on the exchange of technical knowledge, another associated factor.

[12]This material draws on Schroeder, Espinosa and Goodwin; broader literature review in Palmquest.

where $P_x$ is the price of input x, $R_y$ the price of output y, $\partial z_{ky}/\partial x_y$ is the marginal output of the $k^{th}$ attribute in the production of y from x, and $R_y\partial f_y/\partial z_{ky}$ the value of the marginal product of attribute k in the production of y. The term $R_y\partial f_y/\partial z_{ky}$ is the hedonic price, the marginal implicit price of the $k^{th}$ attribute. Then according to (1), the price paid for a variety is equal to the sum of the implicit prices of the attributes of the variety multiplied by the marginal yields of those attributes.

As a simplifying step, assume the marginal yields and products are constant, that is that $R_y\partial f_y/\partial z_{ky} = B_k$ and $\partial z_{ky}/\partial x_y = z_{kxy}$. Equation (1) then reduces to the linear hedonic pricing function:

$$P_x = \sum_{k=1}^{m} B_k z_{kxy}, \qquad (2)$$

where $B_k$ is the marginal implicit value of the attribute k and $z_{kxy}$ is the quantity of attribute k within each unit of input x entering the production function y. Regressing variety prices on attributes (the $z_{kxy}$'s) gives an estimate of the contributions of the variety attributes to the price, that is, the implicit price of the attributes.

For soybean farmers the model can be described as:

$$PRICE_i = \sum_i V_k C_{ik} + e_i, \qquad (3)$$

with i identifying an individual variety, PRICE is price (in 50 pound bags), V the market value of the trait k (to be estimated), and C the quantity measure of trait k contributed by variety i. Finally, e is a random error term.

Soybean farmers in New York and other states have an unbiased source of information about the productive merits of competing varieties available in the form of public yield tests. These tests have the advantage of standardized treatment so that results can be compared across test locations and, to a lesser extent, states. For this study the NY test results for 1992 were used (Wright and Cox 1993). There, as elsewhere, private firms cover expenses for inclusion but public varieties are tested without charge. Data are provided on three relevant production characteristics, yield, proneness to lodging (increasing scale 1 to 5), and plant height. Disease resistance would be valuable information but is difficult to test on a systematized basis. Similarly, component content is not evaluated, largely because of the absence of a broad-based price premium system[13]. For the purpose of the analysis it is

[13]In 1992 Wright and Cox provided an irregular publication including additional attributes (color, disease prevalence and oil and protein composition) of the 1991 soybean trials. Regarding disease it was concluded, "The presence and severity of disease in the seeds was generally low in 1991" (p. 2).

assumed these data are used in part in variety selection choices and that price differences across varieties reflect the different mix of attributes.

To those attributes were added two others, a bivariate measure (dummy variable) distinguishing between public and private varieties, and a bivariate variable indicating whether the variety was protected under PVPA. The designation of public (e.g., state experiment station) or private status was derived from the identified sponsor of the test (Wright and Cox 1993, p. 7). Public varieties are expected to be priced lower. The certification status was determined from the PVP Office *Official Journal* and recent mimeographed updates through August 1992. For certificates of plant variety protection to have a significant price impact this latter term must have a positive sign and be statistically significant. Note that this test indicates a premium associated solely with protected status and not explainable by yield and other measured attributes. Both public and private varieties in the sample have been protected. One adjustment to these data was made; varieties (four in the data set) with protection granted more than 10 years ago are treated as unprotected. This is done because the commercial life of soybean varieties is on the order of seven years and declining (Studebaker), and beyond a decade any protection premium would not be anticipated.

Data on variety prices were collected in spring 1993 from the breeders for 50 pound bags of untreated seed with no early payment adjustments. Breeders supplied their wholesale price and shipment charge along with a "typical" dealer markup. Because of the source the price data do not necessarily represent the prices actually paid by individual farmers. However, it is felt these data better represent statewide prices than would figures from specific dealers. Moreover, spot checks of retail prices indicated variations of up to ± 10 percent of the price data used here. No systematic pattern regarding public, private or protected varieties was detected.

For the site selected (Aurora in Cayuga county; Wright and Cox 1993, Table 1), a total of 58 varieties were tested. Of those, seven were no longer sold or prices were unavailable. In addition, the eight Canadian varieties were eliminated because cold temperatures during the 1992 season combined with high quality standards meant seed for those varieties is not generally available to NY growers (M. Wright, personal communication), leaving a sample size of 43. The data are summarized in Table 1.

**Table 1: Data Characteristics**

| VARIABLE | DEF | MEAN | RANGE | EXPECTED SIGN | SOURCE |
|---|---|---|---|---|---|
| PRICE | Nat. log of price | $14.32 | 11.00-16.00 | N/A | Breeders |
| PUBLIC | Public or private variety | .16 | 0-1 | - | Wright and Cox 1993, p. 7 |
| PROT | Protected variety under PVPA | .23 | 0-1 | + | PVPO *Official Journal* |
| HEIGHT | Variety height | 39.5 in. | 33-45 | + | Wright and Cox 1993, Table 1 |
| LODG | Lodging Proclivity | 2.45 | 1-5 | - | Wright and Cox 1993, Table 1 |
| YIELD | Yield, bu/acre Mean, four replicates per variety | 55.17 bu/acre | 38.6-67.7 | + | Wright and Cox 1993, Table 1 |

N/A - not applicable - dependent variable

Using the natural log of prices to account for nonlinearities in the relationships, the regression results[14] are shown in Table 2. In general the statistical fit is quite good, with an adjusted $R^2$ of 45 percent and the entire equation significant at the 99 percent level. The target variable, PROT, has the expected sign as do PUBLIC and YIELD. HEIGHT and LODG have opposite from anticipated signs due to interactive effects; taller plants are desirable because lower pods are shaded, making harvest easier, but they tend to lodge more. The separation of those effects is not critical to the analysis but the results do indicate farmers are acting rationally (see below)[15].

[14]The analysis was done using Data Desk v. 4.0 for the Macintosh.

[15]Tauer (personal communication) suggested using a company dummy variable as a proxy for "reputation and general pricing strategy." In New York, however, the nationally better known brands (Asgrow, DeKalb, Pioneer, etc.) are applied almost exclusively to the late (Group II) maturity varieties, seemingly an attribute of the focus on the longer-season major soybean growing areas. However, short season variety growers in New York may use a different reputation index for their own somewhat specialized needs. Imposing an arbitrary selection of brands on the analysis could lead to results which would be difficult to interpret.

**Table 2: Regression Results**

| | | | | | | |
|---|---|---|---|---|---|---|
| LPRICE = | 1.20 - | .087PUBLIC + | .023PROT - | .005HEIGHT + | .051LODG + | .0002YIELD |
| | (12.6) | (5.33) | (1.74) | (-1.89) | (3.77) | (.291) |

$R^2$ = 45% F = 7.95 N = 43

Note: t-statistics in parenthesis

The PROT variable is significant at the 95 percent level (1-tailed test) and, with a positive sign, indicates that protected varieties do have a price premium beyond that explainable by yield and other factors[16]. The practical value of that premium, though, is small; protected varieties on average have only a 2.3 percent higher price, or 32 cents on a $14.00 bag. At that level over 9,000 bags must be sold just to recover the PVPO application fee! It is no wonder the private sector considers PVP certificates to be of low value and is seeking alternatives. Various approaches are being attempted, from patenting to the signing of use agreements by purchasers to supporting adoption of the 1991 UPOV convention as the American Seed Trade Association (ASTA), the national trade association, has done.

The disenchantment with PVPA cannot readily be seen in the decline of certificates granted. Some evidence is there - grants for soybeans down to 33 in 1991 from 47 in 1988 (PVPO) - but due to annual variability the trend is not fully evident. Nor is it possible to examine the proportion of new varieties protected annually, as no figures exist on the number of variety releases. What is evident is the acreage of certified seed production, down a third to 639,000 acres over 1989-91 (Official Seed Cert. Agencies 1989 and 1991). PVPA allows applicants to specify that the "variety be sold by variety name only as a class of certified seed" (7 USC 2483(a)). This clause invokes the scrutiny of the national certified seed system as an enforcement mechanism, a valuable factor given the difficulty of detecting infringement. Yet its utilization fell from 30 percent of certificates in 1974-90 to less than five percent in 1991 (PVPO) and is a further indication of a decline in interest in PBR.

The weak relationship between price and yield (Table 2) is an interesting aspect of the analysis but not directly relevant to the objectives of this article. Normally it would be expected that yield would be a principal variety attribute and closely correlated with price. There are several possible explanations as to why that is not the case. First, it needs be recognized that the data are from variety **trials**; some of the entered varieties perform poorly in New York and would not be expected to sell well. Second, annual weather variability means some varieties performed unusually poorly (or well) in 1992 in a way not reflected in relative prices. Third is the uniform pricing system of virtually all private and many public

[16]Separating statistically the protection effects from yield could be difficult. However there is no evidence in this sample of significant multicollinearity; the r = .22 and in a regression using YIELD as the dependent variable, PROT has a t-ratio of only 1.05.

suppliers which utilizes a single list price regardless of individual variety attributes. Perhaps most likely, according to Pardee (personal communication), a long time observer of seed markets, is the difference in sales effort across brands. While some are offered through cooperatives and other outlets, many are sold by farmer-dealers who are effective salespeople. If this assessment is correct, then seed markets do not function as well as is often imagined. But the margin is likely small, as saved seed is a low cost substitute for purchased seed ("bin competition") and, given that seed costs are about three percent of production costs, the price differences among varieties is trivial even in a low margin business like farming. The fact nonetheless remains that farmers are loyal customers, whether due to risk minimization or personal commitment (see e.g., Schrader, Boynton and Liao).

The other unexpected result is the signs of the HEIGHT and LODG terms. These attributes are highly correlated (r = .63), as taller plants lodge more. Indeed, the purchaser is making an almost direct tradeoff, as one inch in height costs .5 percent less, while a .1 increase in the lodging index increases price by the same amount. Thus while the data do not allow us to distinguish between the height and lodging effects, it is evident that the market prices these attributes efficiently.

## Conclusions

The existence of certificates of PVP is associated with a statistically significant but practically insignificant price premium of 2.3 percent for soybean seed in New York in 1993. This analysis should be replicated for other crops and in other areas. If the results are substantiated, the 2.3 percent clearly is inadequate to support concerns about public performance problems associated with the PVPA, at least for soybean seed in New York. It is also insufficient for private firms to justify using PVP, and indeed supplementary information indicates a decline in its use. With easily-copied products like self pollinating seed, that trend suggests the PVPA provides inadequate incentives for private investment. In an era of declining public funding for agricultural research the public should be concerned about the sufficiency of investment in this critical area.

The 1991 UPOV convention, through the mechanism of dependency payments, provides a means of strengthening PVP. Other approaches include patenting, licensing, and increasing the distinctiveness requirement under PVPA. It exceeds the scope of this paper to consider the relative merits of these approaches, but they should be evaluated prior to acting on the 1991 convention. It appears the dissenters got it wrong; PVPA is not too strong, but rather too weak. Now comes the difficult question of what to do about it.

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